Liquefaction Hazard Zonation Mapping,
Albuquerque-Santa Fe Corridor, New Mexico

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Program Element II: Evaluate Urban Hazard and Risk

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Investigations Undertaken

This study is preparing detailed zonation maps of liquefaction hazards in the central Rio Grande Valley, including metropolitan Albuquerque, river front communities between Bernalillo and Isleta, and adjacent areas of the Albuquerque-Santa Fe corridor. Several lifelines and other facilities supporting the large population in the Rio Grande Valley are exposed to potential liquefaction hazards.

Liquefaction-related ground failure historically has caused extensive structural and lifeline damage in urbanized areas around the world. Past historical earthquakes throughout the world show that the distribution of liquefaction-related damage generally is restricted to areas underlain by low-density, saturated, granular sediments. Given the geologic evidence of past large earthquakes near Albuquerque, broad areas of unconsolidated, saturated Holocene sediments in the inner Rio Grande Valley likely are susceptible to significant liquefaction-related ground failure. Detailed, quantitatively derived liquefaction hazard zonation maps for this region currently do not exist. Development of the hazard maps during this study will provide valuable information for emergency preparedness, mitigation of potential risks, and development planning.

In collaboration with the New Mexico Bureau of Mines and Mineral Resources, we are delineating potential earthquake-induced liquefaction hazards in six 7.5-minute map quadrangles in the Albuquerque-Santa Fe corridor (Figure 1). These six quadrangles (Bernalillo, Los Griegos, Alameda, Albuquerque West, Albuquerque East, and Isleta) cover the inner Rio Grande Valley, which is underlain primarily by unconsolidated sediments flanking the present-day Rio Grande channel. Initial steps in the hazard analysis include: (1) completing detailed 1:24,000-scale late Quaternary geologic maps, (2) compiling shallow geotechnical borehole data, and (3) constructing 1:24,000-scale contour maps showing the historically shallowest groundwater depths. The geologic map is being developed based on previous geologic mapping, previous soil surveys, our analysis of 1:24,000-scale aerial photography taken in 1952, and field reconnaissance mapping. This mapping will be supplemented by interpretations of 1-ft-contour orthophotographic-topographic maps obtained from the City of Albuquerque. Shallow groundwater data are being compiled from catalogs

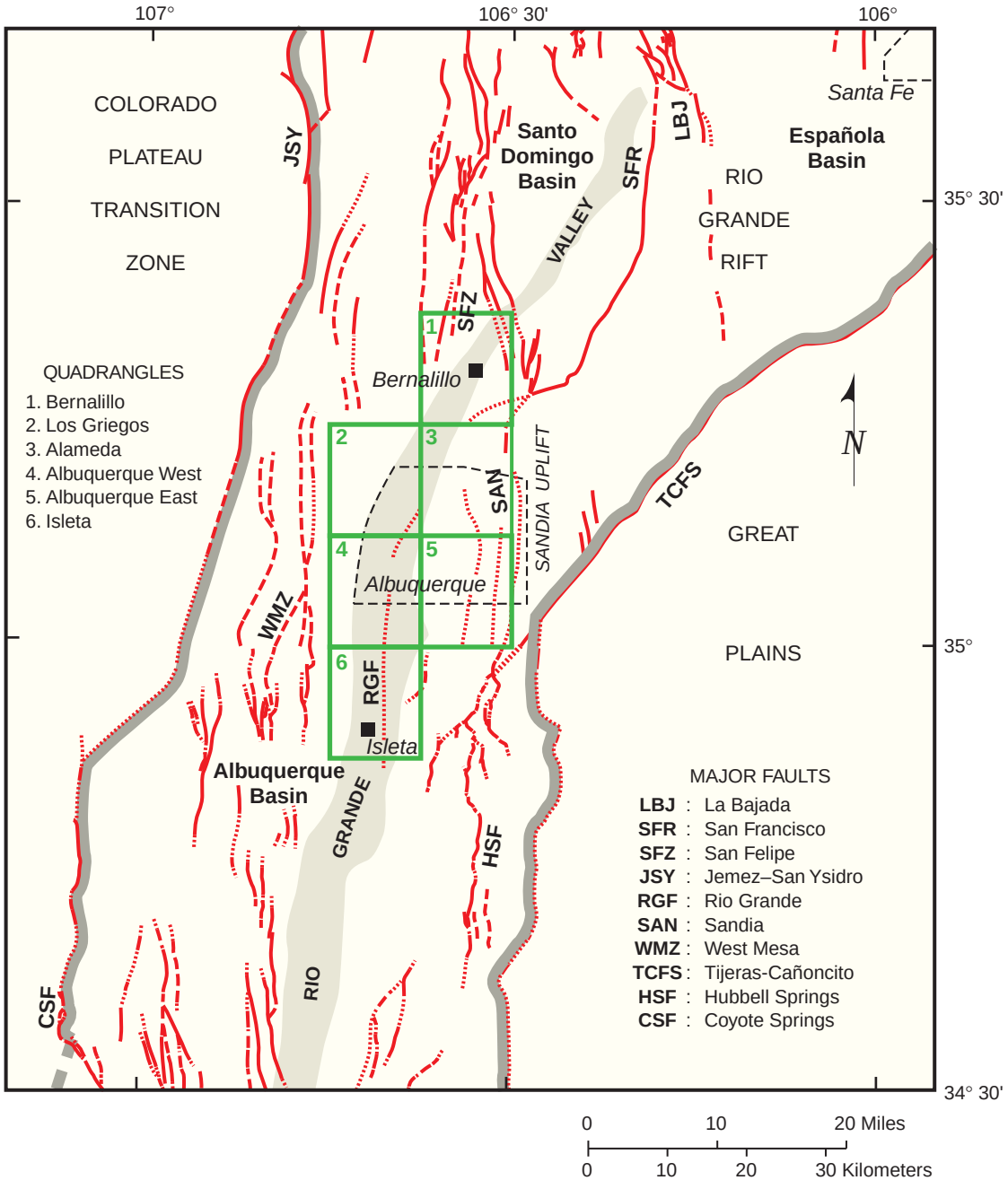

Figure 1. Generalized regional tectonic map of the Rio Grande rift near Santa Fe and Albuquerque showing area of hazard zonation mapping. Stippled area shows the inner Rio Grande Valley, which contains saturated Holocene alluvial and eolian sediments.

provided by the USGS, Water Resources Division. The maps of surficial geologic units and shallow groundwater are being synthesized with subsurface borehole data obtained from various public and private sources. We will construct zonation maps of liquefaction susceptibility based on expected triggering threshold levels of ground motions determined using available borehole data and, where borehole data are unavailable, by a combination of a decision tree and criteria matrix (Figure 2). The criteria matrix incorporates factors such as sediment texture, age, and density, and groundwater depth, and has been implemented in our previous susceptibility mapping of the San Francisco Bay area and of Ventura County, California. Maps of maximum expected amounts of seismically induced ground settlement and lateral spreading will be constructed using published empirical relations and a selected earthquake scenario.

Anticipated results from this analysis will include 1:24,000-scale maps of the inner Rio Grande Valley that depict: (1) late Quaternary geologic units, (2) historically shallowest groundwater depths, (3) liquefaction susceptibility, (4) maps showing the thickness of potentially liquefiable sediments, (5) maximum potential ground settlement, and (6) potential lateral spread displacements.

Results

At this time, we have obtained a large catalog of groundwater data from the USGS Water Resources Division in Albuquerque, and have sorted these data into groups based on location, depth to groundwater, depth of screened interval, and year of measurement. Because of the deep groundwater levels outside of the inner Rio Grande Valley, we are restricting our analysis to the inner valley. We note that liquefaction susceptibility is likely low to very low on the Sandia Mountains piedmont (east of the Rio Grande Valley) and the Llano de Albuquerque (west of the valley). Our database includes only wells that have groundwater levels shallower than 100 feet, acknowledging that areas underlain by groundwater less than about 40 feet typically have low to very low liquefaction susceptibilities. In addition, we restrict our groundwater depth analysis to only those wells with screened intervals shallower than 100 feet, to ensure that we are only assessing groundwater depths of the shallow, unconfined aquifer. We note that municipal pumping in the inner valley began to substantially influence shallow groundwater levels in the early 1960s, and divided the database into pre-1960 data and post-1960 data. In this way, we are assessing present shallow groundwater conditions, as well as the “natural” (e.g., pre-drawdown) conditions. Because of pumping drawdown, there probably are local areas in the inner valley that presently are less susceptible to liquefaction than under natural conditions. However, our preliminary results show that much of the inner valley is characterized by groundwater depths of less than 20 feet, and thus may be susceptible to liquefaction hazards.

Data from numerous shallow boreholes are needed to adequately evaluate subsurface conditions throughout an area as large as the inner Rio Grande Valley. We are collaborating with Bill Haneberg and Sean Connell of the New Mexico Bureau of Mines and Mineral Resources, and Jody Clark of New Mexico Tech to improve their database of subsurface conditions. Ms. Clark has developed a database of subsurface conditions from approximately 130 wells in the inner valley. As might be expected, this database contains several clusters of individual wells, leaving large areas that are relatively uncharacterized. We are exploring options for augmenting this database to provide more extensive coverage, including contacting private consulting firms and additional public agencies. Because we anticipate that there may not be sufficient subsurface data to adequately characterize some large areas of the inner valley through borehole data alone, we are delineating surficial geologic units throughout the inner valley. Geologic mapping enables extrapolation of borehole data to similar geologic units that lack borehole data, thus providing a means for characterizing liquefaction hazards throughout the study area. To this end, we have obtained 1:24,000-scale, black-and-white aerial photography of the inner valley, and are initiating our analysis of these photos.

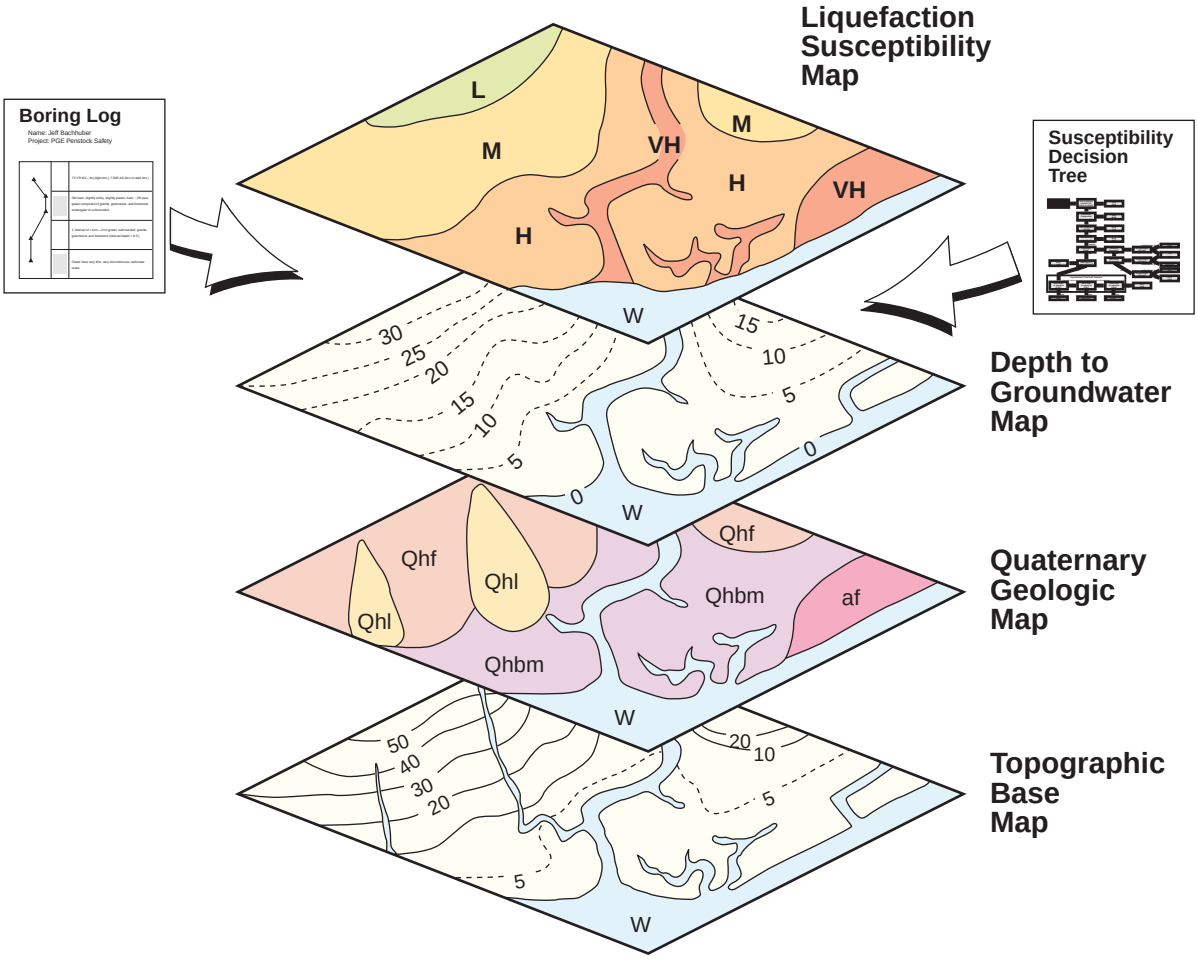

Figure 2. Data sources and integration procedures to produce a liquefaction susceptibility map.

Nontechnical Summary

Liquefaction-related ground failure historically has caused extensive earthquake damage in urbanized areas. This study will identify areas near Albuquerque that are susceptible to liquefaction-related ground failure. Through geologic and geotechnical analysis of sediments in the inner Rio Grande Valley, this study will produce 1:24,000-scale maps showing areas underlain by sediments that may liquefy during an earthquake. This study will also generate maps showing the locations and expected amounts of ground settlement and ground failure resulting from liquefaction. These maps may be used for emergency response, planning, engineering, and risk mitigation purposes.

Reports Published

No reports have been published yet as a result of this study. However, we presented a poster at the Second Annual Workshop for the Middle Rio Grande Basin Study, which took place on February 10-11, 1998, in Albuquerque. The poster was authored by K.I. Kelson, C.S. Hitchcock, W.C. Haneberg, and S.D. Connell, and was titled, “Liquefaction hazard zonation mapping, Albuquerque-Santa Fe corridor, New Mexico”. The poster summarized our approach and allowed for interaction with active researchers in the Albuquerque-Santa Fe area. Proceedings from the workshop are presented in:

Slate, J.L. (ed.), 1998, U.S. Geological Survey Middle Rio Grande Basin Study—Proceedings of the Second Annual Workshop, Albuquerque, New Mexico, February 10-11, 1998: U.S. Geological Survey Open-File Report 98-337, 91 p.